(12) UK Patent Application (19) GB (11) 2 326 564 (13) A

(43) Date of A Publication 23.12.1998

(21) Application No 9713250.0

(22) Date of Filing 20.06.1997

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(51) INT CL^6
H04Q 7/22 7/32 // H04L 12/56 , H04Q 7/30

(52) UK CL (Edition P)
H4L LDGP L1H10

(56) Documents Cited
EP 0700225 A2 WO 96/37079 A1

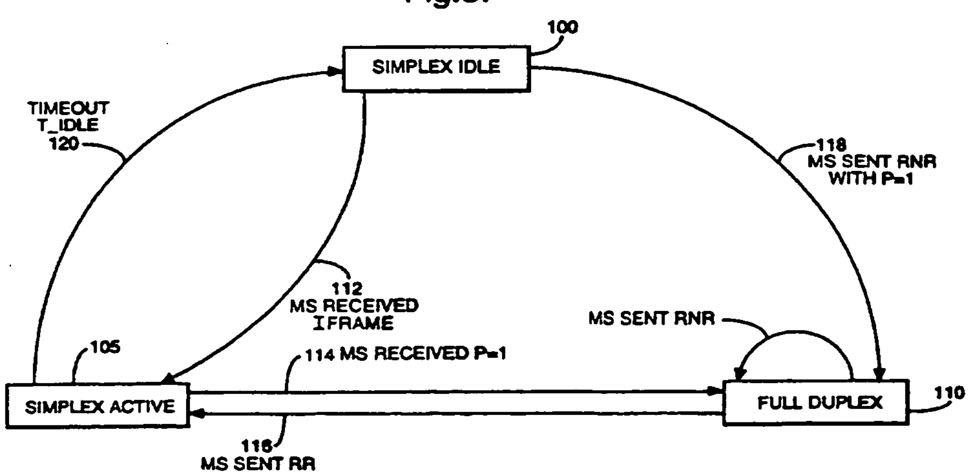
(58) Field of Search
UK CL (Edition O) H4L LDB LDG LECX
INT CL^6 H04L 12/56 , H04Q 7/22 7/24 7/30 7/32
ONLINE DATABASE: WPI

(54) Abstract Title

Transmitting data on high and low capacity channels in a radio communication system

(57) A radio communication system in which packet data is transmitted between a base station and a mobile station via a high capacity, high speed one way channel or a low capacity, low speed two way channel. A mobile station can be in an idle mode 100 waiting to receive data packets on the high capacity simplex channel, in a first active mode 105 in which it receives via the high capacity channel, or in a second active mode 110 in which it transmits or receives via the low capacity duplex channel. The mobile switches from idle mode to first active mode when the base station initiates a data transaction, switches from idle mode to second active mode when the mobile initiates a transaction and switches between active modes after a completed transaction. On switching to the second active mode after a completed transaction in the first active mode the mobile station determines whether to initiate a transaction (transmit data) or return to the first active mode. After a predetermined time where there are no transactions the mobile station returns 120 to the idle mode. In the second active mode the base station is barred from initiating a data transaction.

Fig.5.



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The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1995
This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.

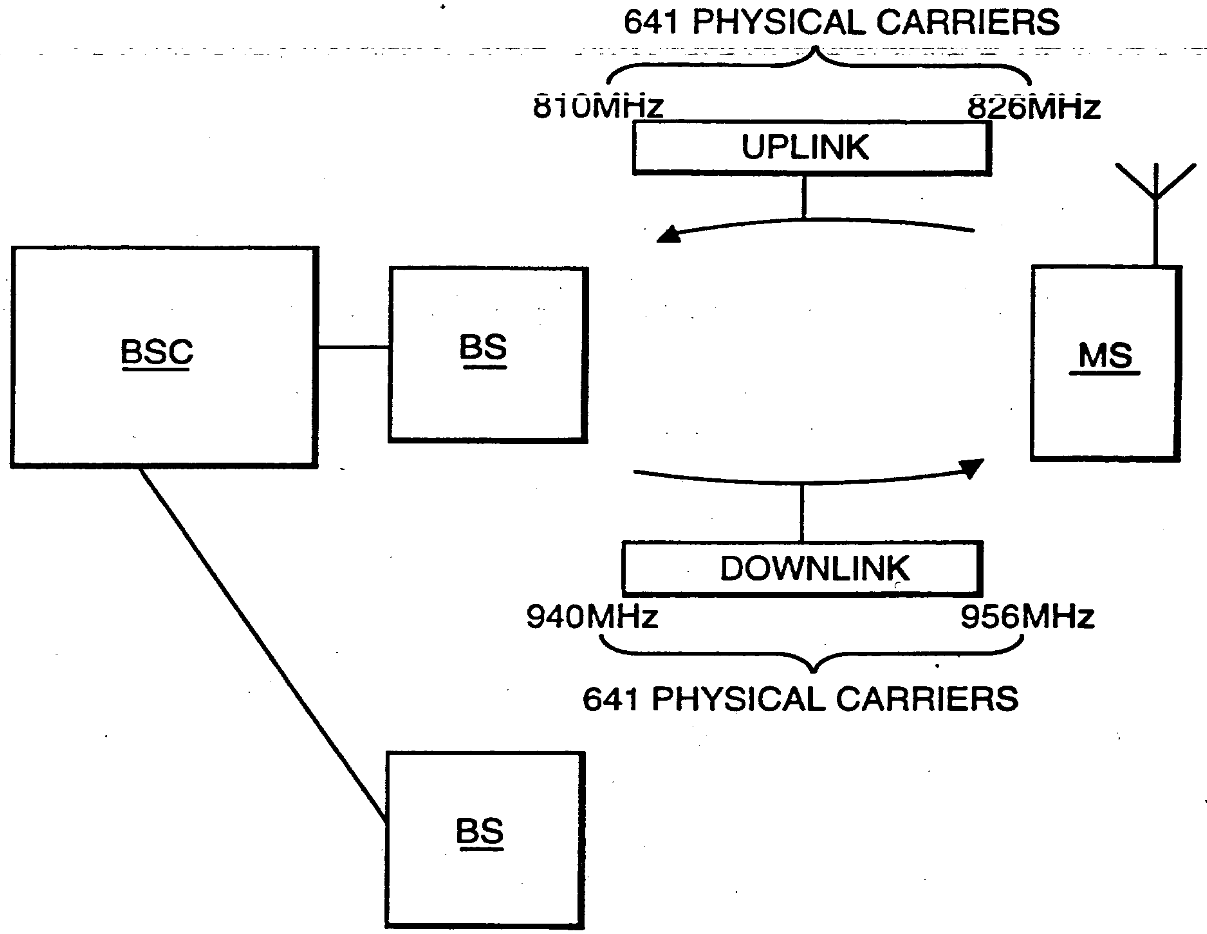

641 PHYSICAL CARRIERS
810MHz
826MHz
UPLINK
BSC
BS
MS
DOWNLINK
940MHz
956MHz
641 PHYSICAL CARRIERS
BS

Fig.3.

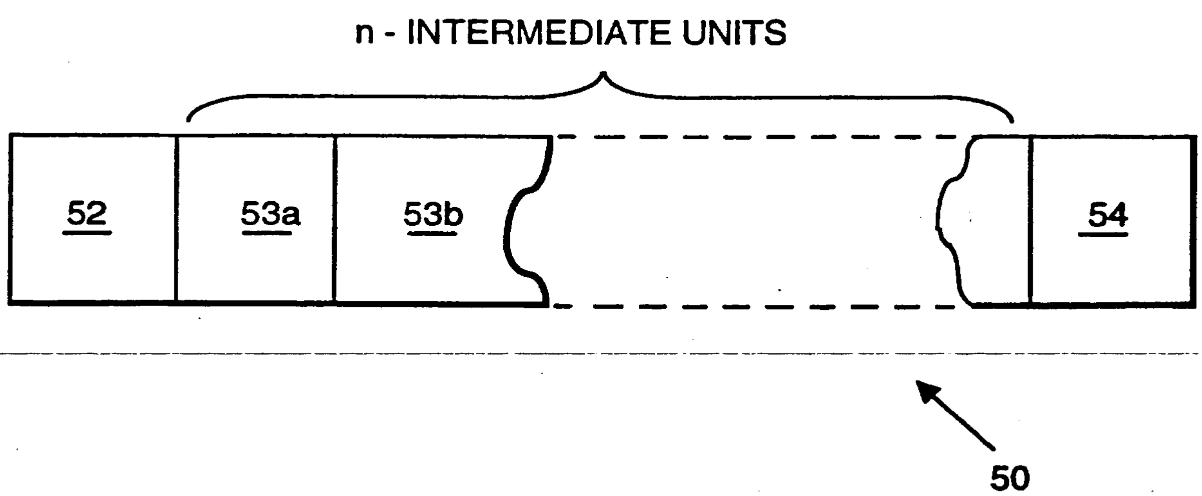
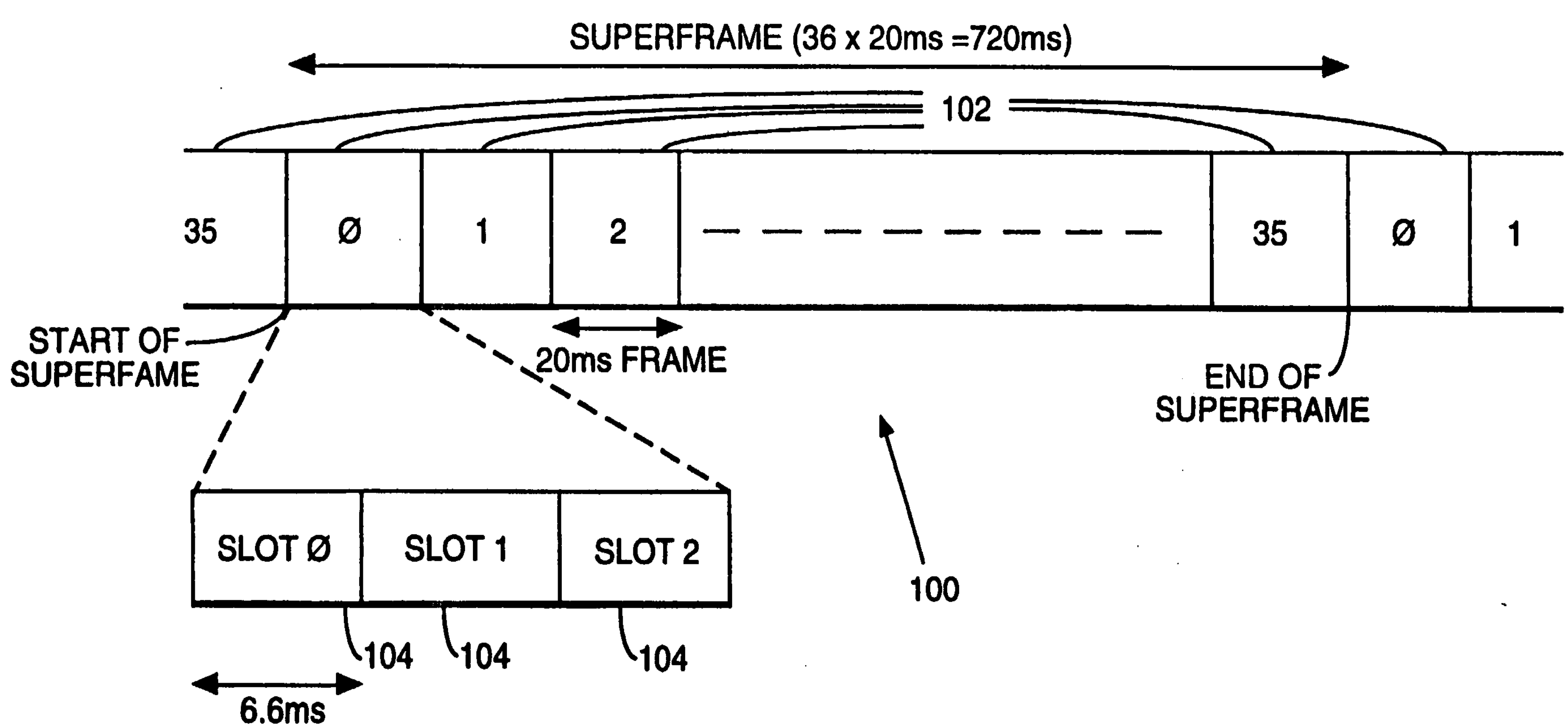
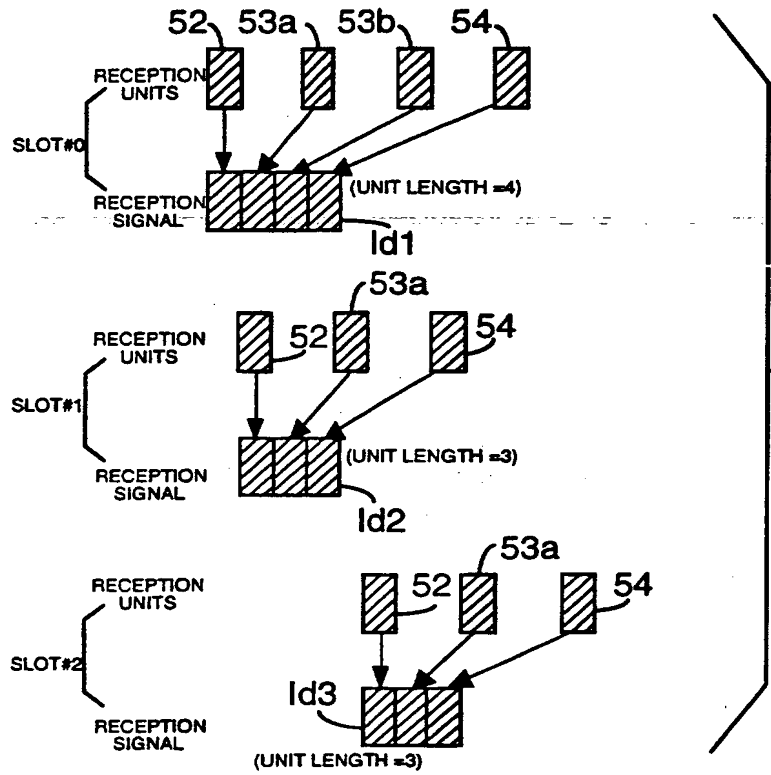

n - INTERMEDIATE UNITS
52
53a
53b
54
50

Fig.2.

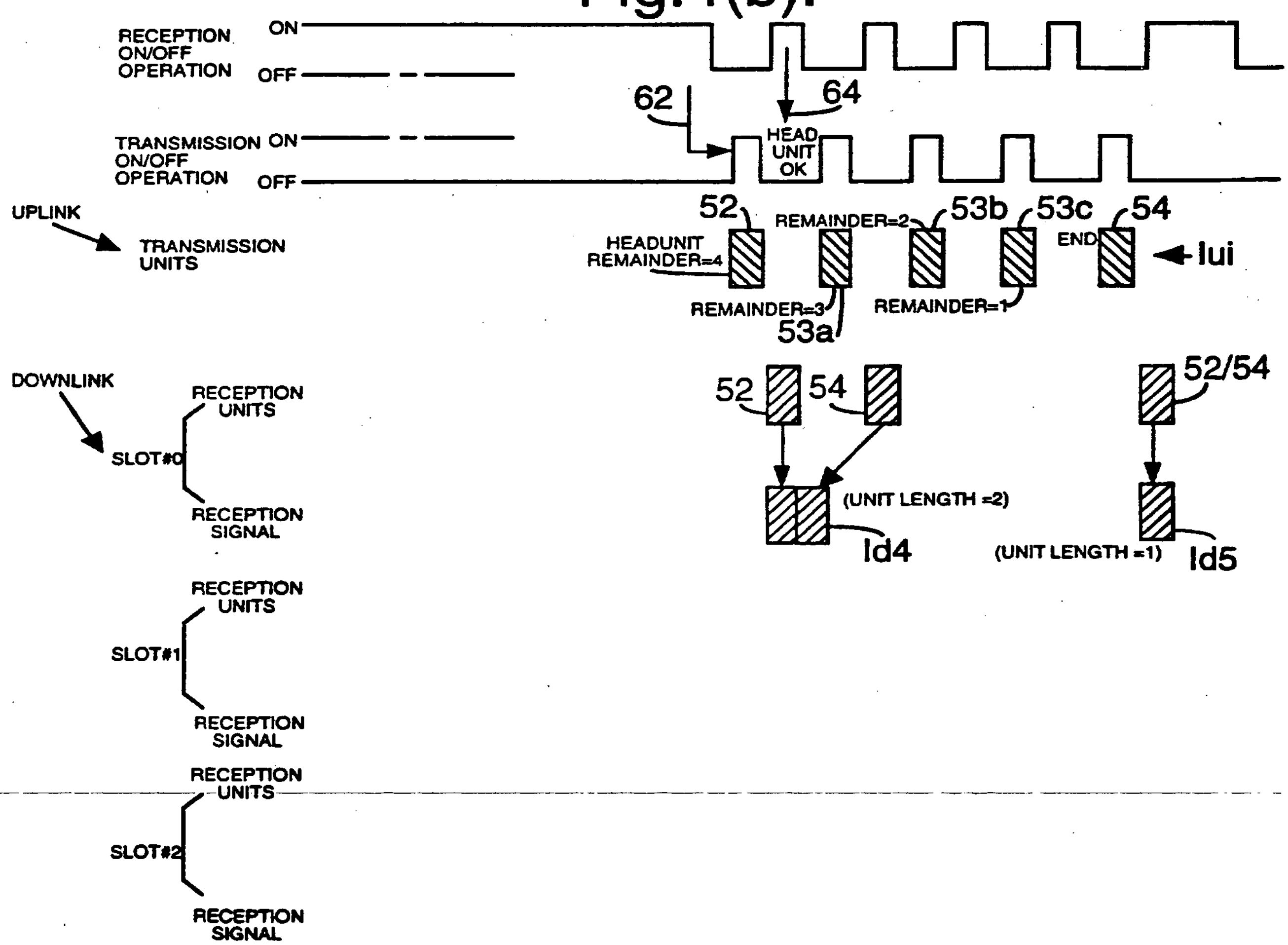

SUPERFRAME (36 x 20ms =720ms)
102
35
Ø
1
2
35
Ø
1
START OF SUPERFAME
20ms FRAME
END OF SUPERFRAME
100
SLOT Ø
SLOT 1
SLOT 2
104
104
104
6.6ms



52
53a
53b
54
RECEPTION UNITS
SLOT#0
RECEPTION SIGNAL
(UNIT LENGTH =4)
Id1
53a
52
54
RECEPTION UNITS
SLOT#1
RECEPTION SIGNAL
(UNIT LENGTH =3)
Id2
53a
52
54
RECEPTION UNITS
SLOT#2
RECEPTION SIGNAL
Id3
(UNIT LENGTH =3)
DOWNLINK

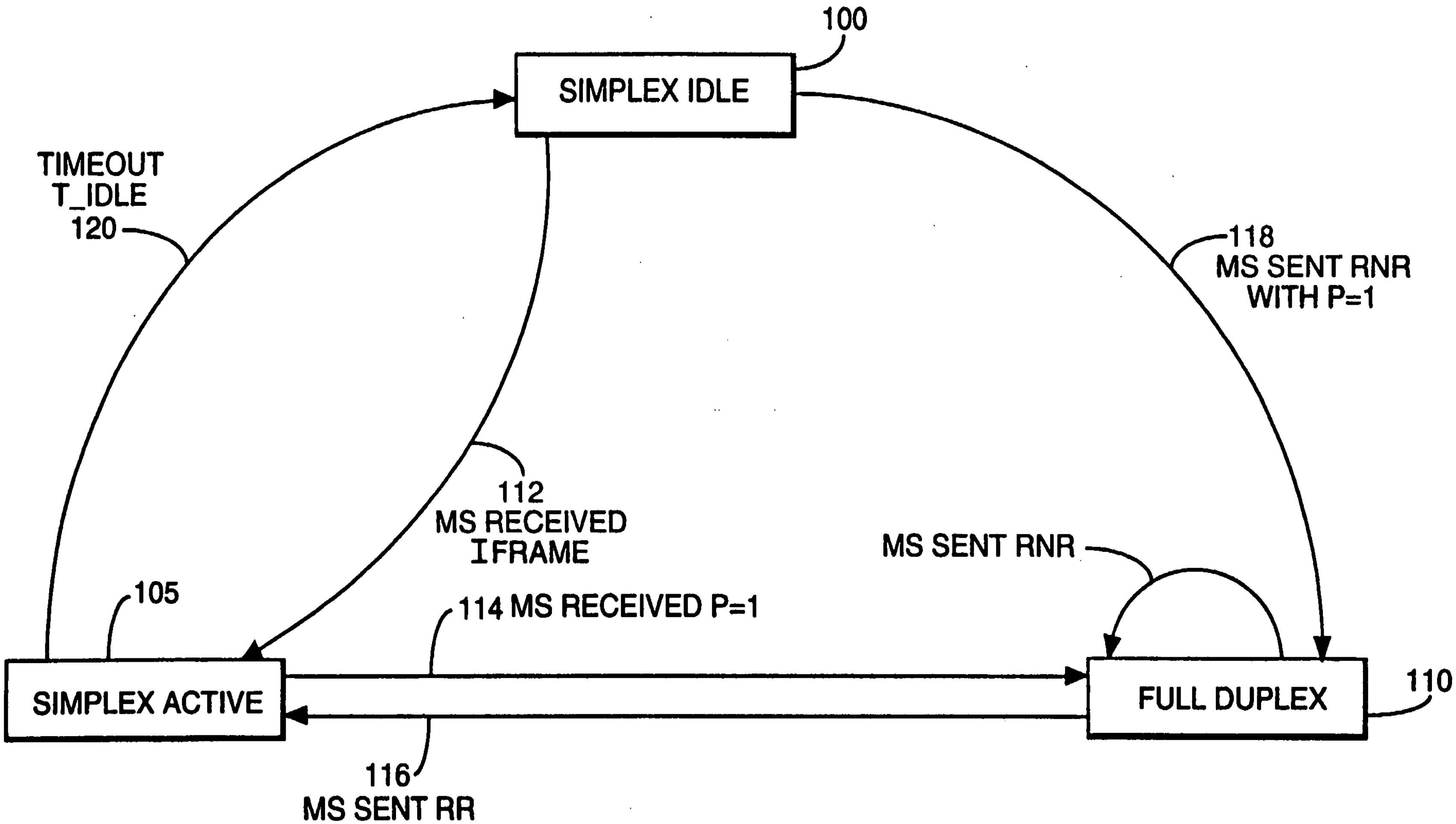
Fig.4(a).

Fig.4(b).



RECEPTION ON/OFF OPERATION
ON
OFF
62
64
HEAD UNIT OK
TRANSMISSION ON/OFF OPERATION
ON
OFF
UPLINK
TRANSMISSION UNITS
52
HEADUNIT REMAINDER=4
REMAINDER=2
53b
53c
54
END
Iui
REMAINDER=3
53a
REMAINDER=1
DOWNLINK
RECEPTION UNITS
SLOT#0
RECEPTION SIGNAL
52
54
(UNIT LENGTH =2)
Id4
52/54
(UNIT LENGTH =1)
Id5
RECEPTION UNITS
SLOT#1
RECEPTION SIGNAL
RECEPTION UNITS
SLOT#2
RECEPTION SIGNAL

Fig.5.


100
SIMPLEX IDLE
TIMEOUT
T_IDLE
120
118
MS SENT RNR
WITH P=1
112
MS RECEIVED
IFRAME
MS SENT RNR
105
114 MS RECEIVED P=1
SIMPLEX ACTIVE
FULL DUPLEX
110
116
MS SENT RR

2326564

PACKET DATA

The present invention relates to packet data communication in a telecommunication system, especially but not exclusively the RCR-27 personal digital cellular system.

In a cellular telecommunication system comprising base stations and subscriber mobile stations, many packet transactions between the subscriber mobile stations and the base stations make very heavy use of the downlink but relatively light use of the uplink between the base stations and the mobile stations. Internet applications exemplify this since most data flow takes place from the Internet to the subscriber via the downlink. Other examples are electronic mail or file transfer.

With this consideration in mind, the present invention provides a method, and a telecommunication system, in which the format of a channel for packet communication is varied according to the nature of the packet transaction. Also, more specifically, the present invention, in one aspect, provides a way in which the transition between channel formats can be co-ordinated.

Within the confines of a given system protocol and the specific hardware of a system, this allows the telecommunication system to manage the characteristics of the packet channel to best suit its need.

Exemplary embodiments of the invention are hereinafter described with reference to the accompanying drawings, in which:

Figure 1 shows a portion of the structure of RCR system and illustrates the frequency allocation in the 800 MHz frequency band;

Figure 2 illustrates the structure of a superframe in the RCR system;

Figure 3 shows the structure of an I-frame or layer 2 unit;

Figure 4(a) and 4(b) show examples of packet transactions between a base station and a mobile station; and

Figure 5 shows a state diagram illustrating the operation of a base station in accordance with the present invention.

The Japanese RCR-27 personal digital cellular system is a Time Division Multiple Access (TDMA) system. An overview of the RCR-27 system is given below to facilitate understanding of the invention.

Referring to Figure 1, a base station controller BSC is linked to a plurality of base stations BS of which only two are shown for illustration purposes. The base station controller BSC is a layer 2 entity (of the standard seven layer OSI model) and directs the operation of its base stations BS. Communication between a base station BS and a mobile station MS takes place via two discrete frequency bands, one reserved for communications from the base station BS to the mobile station MS, the downlink, and one reserved for communication from the mobile station MS to the base station BS, the uplink, as illustrated in Figure 1. In the example in Figure 1, the downlink accommodates 641 physical carriers between 810 MHz and 826 MHz at 25 kHz intervals. For each physical carrier in the downlink, there is a corresponding physical carrier in the uplink. In the uplink, the physical carriers are also at 25 kHz intervals located between 940 MHz and 956 MHz. The base station BS is a high specification device capable of simultaneous transmission via the downlink and reception via the uplink. In contrast, the mobile state MS is a portable and inexpensive consumer device which is incapable of simultaneous transmission and reception.

Each physical carrier has data transmitted on it in the form of a superframe. Referring to Figure 2, each superframe 100 consists of 36 (0 . . . 35) frames of 20

ms duration and each frame 102 consists of three slots 104 (0 . . . 2) each of 6.6 ms duration. A superframe lasts 720 ms. Each frame can be assigned the role of either a user traffic channel TCH or a control channel CCH. The superframes in the uplink and downlink are transmitted with a small offset in time. The uplink control channels are common access whereby any mobile station MS can apply to the base station BS to use the channel at any opportunity.

In order to register with the base station BS, the mobile station MS scans a subset of the downlink physical carriers which have been predefined by the network operator as being perch channels. The signal strength on each perch channel is ascertained and arranged in signal strength order. Starting with the perch channel having the strongest received signal strength, the mobile station MS attempts to synchronise and decode the data in slot 2 of the perch channel. This slot is assigned to a control channel, more particularly the broadcast control channel BCCH. The broadcast control channel BCCH contains information about the cell or zone including, for example, the control channel structure, network identity, location area, neighbouring zones, restrictions on use and the like. The BCCH information also includes information indicating which slots have been reserved for the role of the user packet channel UPCH. This UPCH information is in the form of data indicating the physical carrier and the slot of the superframe transmitted on that physical carrier.

If the BCCH information is not decodable from the perch channel with the highest received signal strength, the mobile station MS tries the perch channel with the next highest received signal strength and so on.

Having decoded the BCCH information, the mobile station MS is able to make a request to be registered in the cell or zone. Having been registered with the base station BS, the MS station enters standby mode. In standby mode, the MS station wakes up only during those slots of the control channel CCH superframe which have been assigned the role of paging channels PCH in order to monitor whether it is being paged by the base station BS for a packet or voice transaction.

Data is transmitted as a sequence of I-frames or layer 2 (of the standard OSI seven layer model) LAPDm units. As shown in Figure 3, each I-frame comprises a head unit 52, an end unit 54 and any number of intermediate units 53. Each unit occupies a single slot of the user packet channel UPCH. Each I-frame includes a polling bit P. If the polling bit P is set to 1, this is an invitation to the station MS/BS which just received the I-frame to provide an acknowledgement signal.

Because the uplink control channels, including the user packet channel UPCH, are common access (and so a collision detection mechanism is needed) and because the mobile station MS lacks the hardware to simultaneously transmit and receive, packet data transactions between the base station BS and the mobile station MS are carried out in two modes which are illustrated in Figures 4(a) and 4(b).

Figure 4(a) shows at the layer 1 level one mode of operation in which the packet channel UPCH between the base station BS and the mobile station MS is configured to adopt a high capacity/high speed simplex (downlink only) channel format. In this (so-called 'multi-slot') channel format, the maximum number of 3 slots per frame is allocated to carry packet data. In the 4 frames illustrated, the base station BS sends three I-frames I_{d1}, I_{d2}, and I_{d3} via the downlink. I_{d1} comprises a head unit 52, 2 intermediate units 53a, 53b and an end unit 54 and is transmitted on slot 0. I_{d2} comprise a head unit 52, 1 intermediate unit 53a and an end unit 54 and is transmitted on slot 1. I_{d3} comprises a head unit 52, intermediate unit 53a and an end unit 54 and is transmitted on slot 2.

Figure 4(b) shows at the layer 1 level another mode of operation in which the packet channel UPCH between the base station BS and the mobile station MS is configured to adopt a low capacity/low speed full duplex channel format. In this (so-called 'single-slot') channel format, a single designated slot of the frames in both the uplink and downlink directions is allocated to carry packet data. In the example shown, I_{u1} is being transmitted in the first 5 frames in the uplink direction on slot 0. I_{u1} comprises a head unit 52, 3 intermediate units 53a, 53b, 53c and an end unit 54. Because the uplink of the UPCH channel is common access (between the mobile

stations MS), a collision control mechanism needs to be employed. The operation of the collision control mechanism is illustrated by arrows 62 and 64 in Figure 4. Arrow 62 represents the mobile station MS decoding the idle/busy flag associated with slot 0 in the current frame of the downlink which indicates whether the corresponding uplink slot is currently in use. If it is 'idle', as it is in this case, the mobile station MS transmits on the corresponding uplink slot the head unit 52 of the I-frame I_{u1}. The mobile station MS then waits on slot 0 of the next frame for a response from the base station BS. Arrow 64 represents the response of the base station BS. Arrow 64 comprises a partial echo PE and a receive/not receive flag R/N. The partial echo is a CRC check sum. If the partial echo PE matches that for the head unit 52 which was transmitted and the R/N flag indicates that the head unit 52 was successfully received, as it is in this case, then the mobile station MS assumes that it has been allocated the slot 0 for transmission of further units of the I-frame during subsequent frames and proceeds with this transmission as shown. In the case (not illustrated) where uplink access is not gained, for example, because of collision with another mobile station MS, the mobile station MS attempts to gain uplink access after a random retransmission interval. I_{d4} is being transmitted in the first 2 frames in the downlink direction on slot 0. I_{d4} comprises a head unit 52 and an end unit 54. In the sixth frame I_{d5} is transmitted in the downlink direction. It comprises only a head/end unit 52/54.

Reception on the downlink and transmission on the uplink on the same logical slot by the mobile station MS (which is incapable of simultaneous transmission and reception) is possible because of the time offset between the uplink and downlink.

Referring to Figure 5, initially once a link between the mobile station MS and the base station BS is established, the mobile station MS is in the Simplex Idle state 100 in which it monitors the downlink of its UPCH channel and listens for a packet data transaction in the multi-slot channel format. The base station BS monitors the uplink. From this setting, two scenarios can develop.

Scenario 1: the base station BS has data for transmission.

Once the base station BS has data for transmission to the mobile station MS, it may proceed immediately with transmitting this data via the downlink of the UPCH channel allocated to the mobile station MS. Transmission takes place in the multi-slot channel format illustrated by Figure 4(a) and can comprise any number of I-frames. Arrow 112 illustrates the state change of the mobile station MS to the Simplex Active state 105 which this operation entails. The last I-frame of this transaction is coded to indicate to the mobile station MS that it constitutes the final I-frame of this transaction. This coding takes the form of setting the polling bit P to 1 in the head unit 52. In practice, the number of I-frames which are sent consecutively in this mode is kept below a relatively low level, even if there is much more data to be sent from the base station BS, because while in this state the mobile station MS is unable to communicate with the base station BS to, for example, verify that it has correctly received an I-frame or request retransmission of a corrupted I-frame. At the end of the transaction, the mobile station MS switches to the Full Duplex state 110 illustrated by arrow 114.

If the mobile station MS does not have data for transmission to the base station BS, it sends a token, for example, including the receiver ready flag, RR, via its designated slot of the uplink of its UPCH channel which indicates that it has no data to transmit itself and that it will return to the Simplex Active state 105. Arrow 116 illustrates the state change which this operation entails. If there was some data loss in the last transaction, the token can serve as more than a mere acknowledgement but also constitute a request for retransmission of the lost data.

On the other hand, if the mobile station MS has data for transmission to the base station BS, it sends a token, for example, including the receive not ready flag, RNR, via the designated slot of the uplink of its UPCH channel. Transmission may then take place in the single-slot channel format illustrated by Figure 4(b). This is described further below in Scenario 2.

Either the RNR or RR flag, depending on the situation, constitute an acknowledgement from the mobile station MS to the base station BS to the setting of the polling bit P to 1 (indicating the end of the transaction). If the base station BS does not receive this acknowledgement after a predetermined period, it transmits a token via the designated slot of the downlink of the UPCH channel allocated to the mobile station MS. This token takes the form of the RR with the polling bit P set to 1. The base station BS retransmits this token until it receives a response from the mobile station MS.

Scenario 2: the mobile station MS has data for transmission.

Before the mobile station MS can transmit data, it must first switch from the Simplex Idle state 100 to the Full Duplex state 110 as illustrated by the arrow 118. The mobile station MS sends a token, including, for example, the RNR flag with the polling bit set to 1 via the designated slot of the uplink of its UPCH channel. The RNR flag signals to the base station BS that the mobile station MS has changed state and thus intends to transmit data. As a result, the base station BS is barred from initiating a high data rate/ multi-slot channel format transaction as shown in Figure 4(a) and particularly illustrated by arrow 112 in Figure 5. The base station BS then in reply acknowledges receipt of the RNR flag by signalling a RR flag via the designated slot in the downlink of the UPCH channel allocated to the mobile MS.
If the mobile station MS does not receive the RR flag, it retransmits the RNR flag with the polling bit set to 1.

The mobile station MS then proceeds with the transmission of data in the single-slot format and as illustrated in Figure 4(b). It will be appreciated from the description of Figure 4(b) that at the layer 1 level full duplex communication is possible. However, in this preferred embodiment of the invention, the single downlink designated slot is used only to transmit control data, for example, to acknowledge uplink data and where appropriate report data loss in the uplink transmission. This is done in order to minimise the duration for which it is necessary to be in the single-slot channel format. In other embodiments, the single downlink designated slot can be used to

transmit traffic data too. Once the uplink transmission is complete, this is signalled by the mobile station MS signals to the base station BS by sending a token via the designated slot in the uplink of the UPCH channel. This token takes the form of the RR flag with the polling bit P set to 1. Once the base station BS receives this token the bar on initiating a high data rate/ multi-slot channel format transaction is removed. Once the mobile station MS receives an acknowledgement that the base station BS has received it, it returns to the Simplex active state as illustrated by arrow 116 in Figure 5. The base station BS acknowledgement takes the form of the RR flag.

Once a transaction of some kind has taken place (Scenario 1 and/or Scenario 2), the mobile station MS eventually returns to the Simplex Active state 105 and can repeat either scenario as required. In addition, the mobile station MS includes an idle timer T_IDLE which is re-started when the mobile station MS receives data from the base station BS. If the timer T_IDLE is running for more than a predetermined duration, indicating that no transactions have been required for the predetermined duration, then the mobile station MS switches to the Simplex Idle state 100 as illustrated by arrow 120.

From the foregoing, it will be appreciated that if the mobile station MS is in the Simplex Active state 105 and the base station BS is not transmitting I-frames, the mobile station MS will only get the opportunity to transmit again after it returns to the Simplex Idle state 100 due to the expiry of the timer T_IDLE or after the base station BS has initiated and completed another downlink transaction.

The preferred embodiment of the invention is able to reliably switch between a high capacity simplex channel format and a low capacity full duplex format as needed. As a result, the preferred embodiment is highly suited to downlink intensive applications like the Internet which nonetheless require occasional uplink access.

CLAIMS

1. A method of conducting data transactions between a base station and a mobile station of a cellular radiotelephone system via a variable format channel, in which the mobile station can be in an idle mode in which the mobile station waits to receive via the channel having a high capacity one-way format; a first active mode in which the mobile station receives via the channel having a high capacity one-way format; a second active mode in which the mobile station transmits or receives via the channel having a low capacity two-way format, the method including the mobile station performing the steps of :-

simplex

switching from the idle mode to the first active mode when the base station initiates a data transaction;

duplex

switching from the idle mode to the second active mode when the mobile station initiates a data transaction;

switching between active modes after a completed data transaction; and

after switching to the second active mode after a completed data transaction in the first active mode, determining whether to initiate a transaction in the second active mode or return to the first active mode.

2. A method as in Claim 1, wherein the mobile station returns to the idle mode if after a predetermined duration in the first active mode no data transactions take place.

3. A method as in any preceding claim, wherein the mobile station detects the completion of a transaction in the first active mode by means of a marker included in the transaction.

4. A method as in any preceding claim, wherein the base station detects the completion of a transaction in the second active mode by means of a marker included in the transaction.

5. A method as in Claim 5, wherein the base station detects a flag terminating the transaction in the second active mode which indicates its completion.

6. A method as in any preceding claim, wherein the mobile station signals to the base station the result of said determining step.

7. A method as in any preceding claim, wherein on entering the second active mode the mobile station transmits a signal via the channel which notifies the base station that it has entered the second active mode.

8. A method as in any preceding claim, wherein, in the second active mode, only the uplink of the channel is used for user data.

9. A mobile station which can communicate with a base station of a cellular radiotelephone system via a variable format channel, wherein the mobile station has an idle mode in which the mobile station waits to receive via a channel having a high capacity one-way format; a first active mode in which the mobile station receives via the channel having a high capacity one-way format; a second active mode in which the mobile station transmits or receives via the channel having a low capacity two-way format, wherein the mobile station comprises means for forbidding the initiation by the base station of a data transaction in the first active mode and means for permitting the initiation by the base station of a data transaction in the first active mode.

10. A mobile station as in Claim 9, wherein the forbidding means and the permitting means comprise means for transmitting uplink signals via the channel in the second active mode.

11. A mobile station constructed, arranged and adapted to operate substantially as herein described with reference to the accompanying drawings.

12. A method of conducting data transactions substantially as herein described with reference to the accompanying drawings.

The Patent Office

12

Application No: GB 9713250.0
Claims searched: 1-8

Examiner: Gareth Griffiths
Date of search: 17 September 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4L (LDB, LDG, LECX)

Int Cl (Ed.6): H04L 12/56, H04Q 7/22, 7/24, 7/30, 7/32

Other: Online Database: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	EP700225 A2 (AT&T)	
A	WO96/37079 A1 (QUALCOMM)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Fig.1.

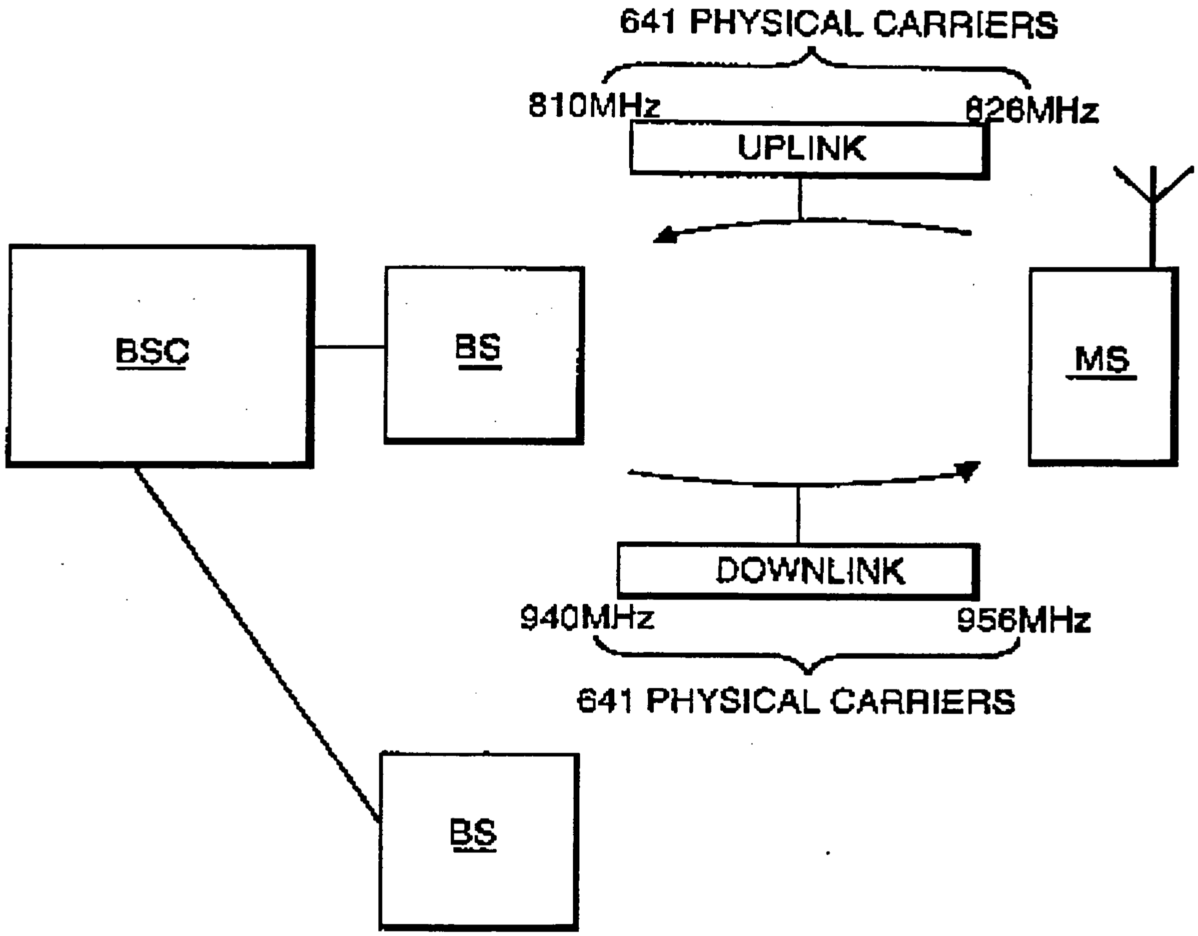

641 PHYSICAL CARRIERS
810MHz
826MHz
UPLINK
BSC
BS
MS
DOWNLINK
940MHz
956MHz
641 PHYSICAL CARRIERS
BS

Fig.3.

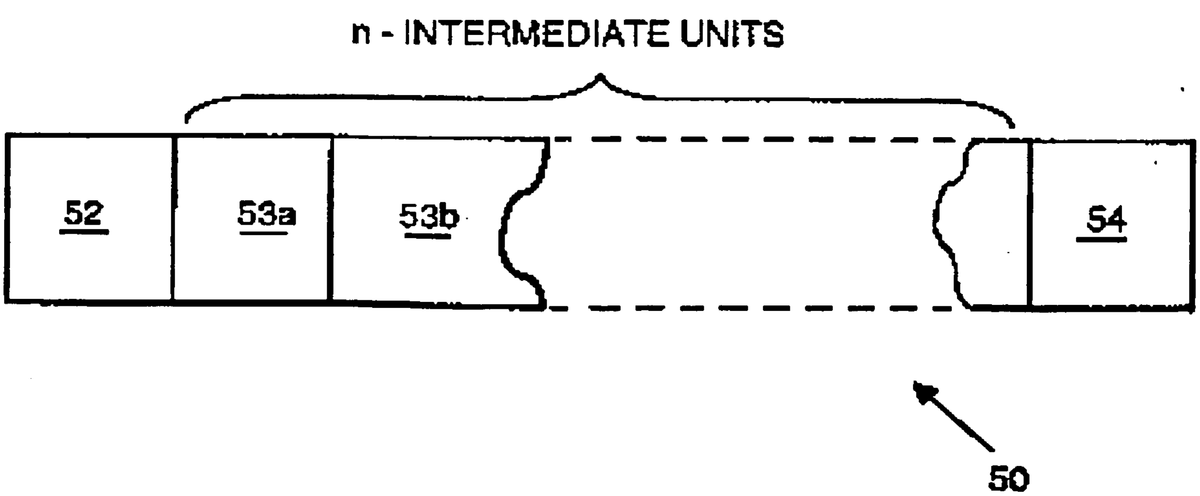
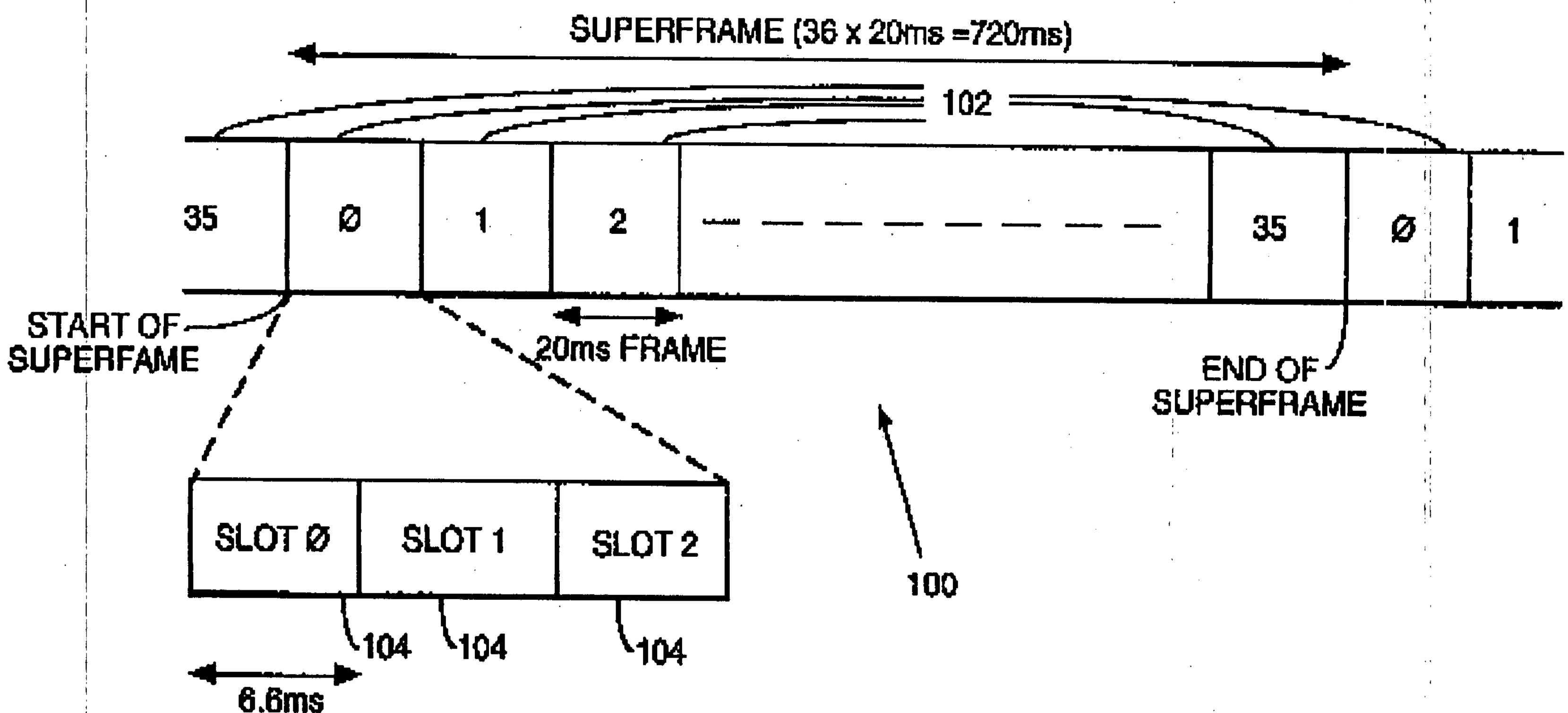

n - INTERMEDIATE UNITS
52
53a
53b
54
50

Fig.2.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102
35
Ø
1
2
35
Ø
1
START OF SUPERFAME
20ms FRAME
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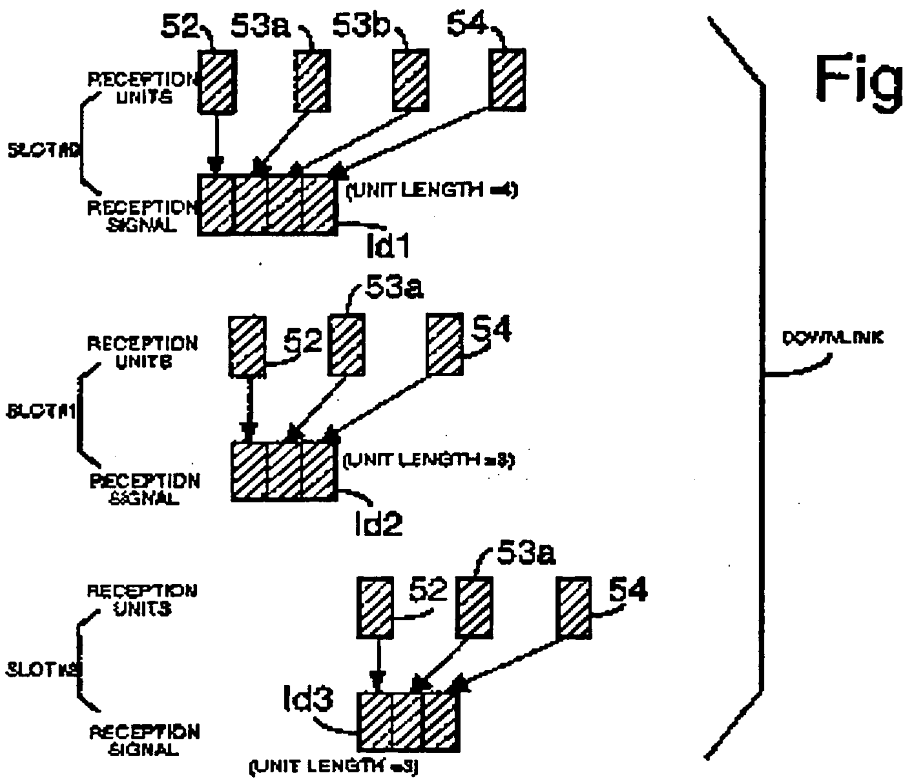
SLOT Ø
SLOT 1
SLOT 2
104
104
104
6.6ms
100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53b
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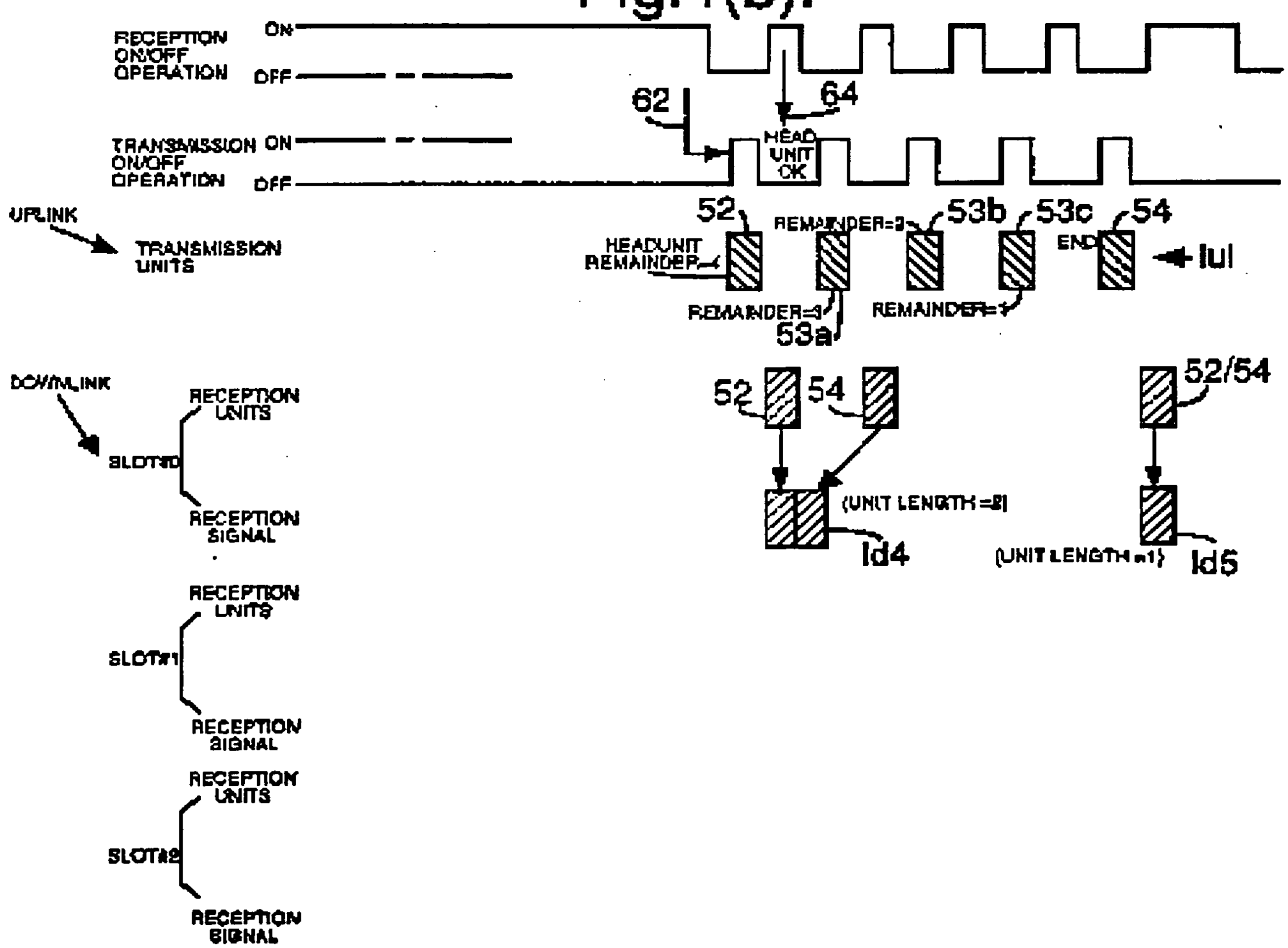
SLOT#1
RECEPTION SIGNAL
(UNIT LENGTH =3)
Id2
53a
52
54
RECEPTION UNITS
SLOT#2
RECEPTION SIGNAL
Id3
(UNIT LENGTH =3)
DOWNLINK

Fig.4(a).

Fig.4(b).


RECEPTION ON/OFF OPERATION
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54
(UNIT LENGTH =2)
Id4
52/54
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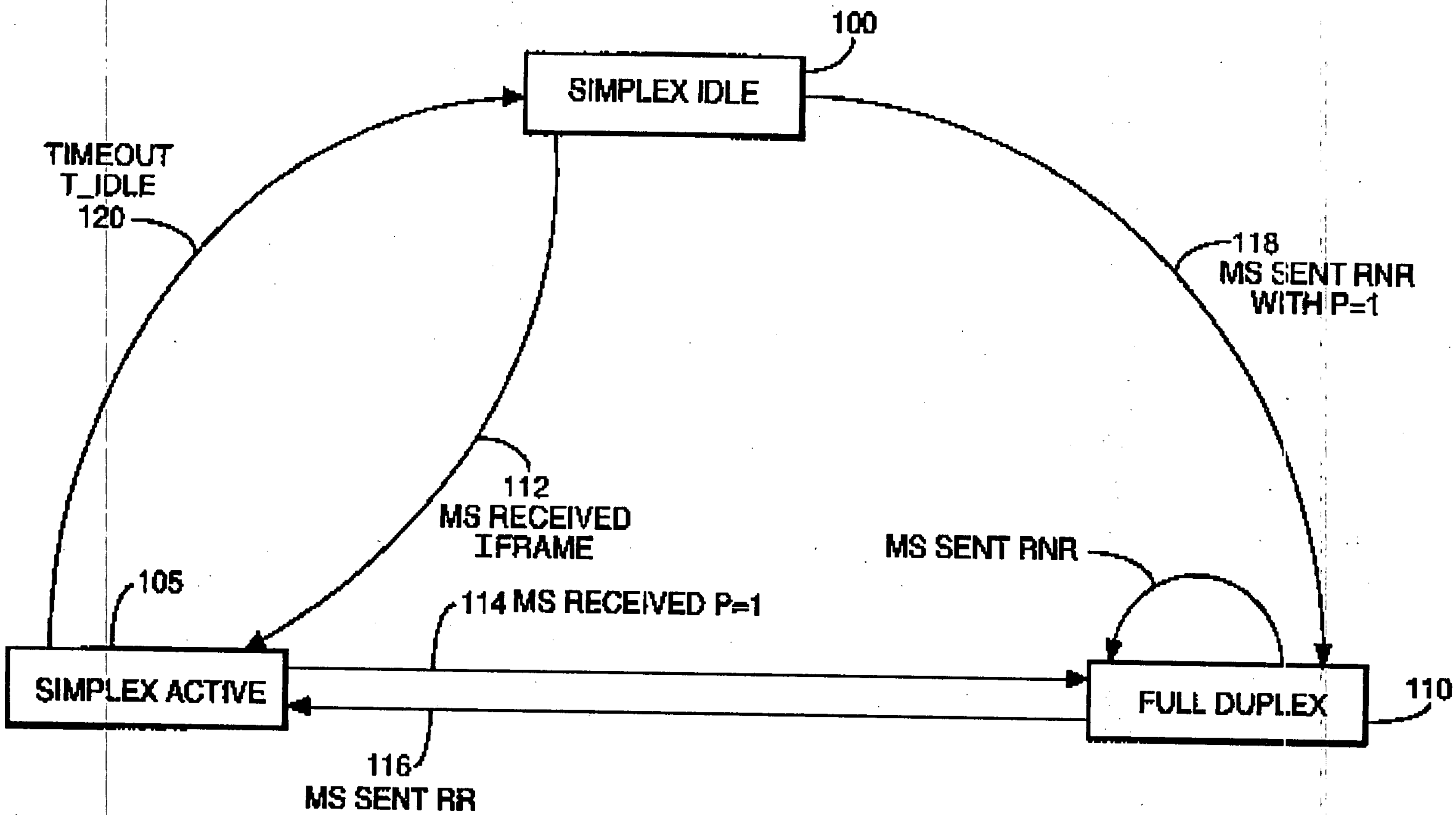
RECEPTION UNITS
SLOT#2
RECEPTION SIGNAL

Fig.5.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118
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WITH P=1
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SIMPLEX ACTIVE
FULL DUPLEX
110
116
MS SENT RR